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November 27, 2017

VIA ELECTRONIC FILING

Marlene H. Dortch, Secretary
Federal Communications Commission
445 12th Street, S.W.
Washington, D.C. 20554

Re: Written *Ex Parte* Notice, GN Docket No. 17-183

Dear Ms. Dortch:

The Boeing Company ("Boeing"), through its counsel, hereby files this letter to address the critical importance of protecting safety-of-life aircraft radio altimeter and wireless avionics intra-communications ("WAIC") systems that operate in the 4.2-4.4 GHz band. Boeing responds to the misleading use of outdated and incomplete information in the reply comments of T-Mobile USA, Inc. to suggest that radio altimeters and WAIC systems may not necessitate the protected use of the entire 4.2-4.4 GHz band – including protection from adjacent band interference – to ensure the safe and efficient operation of commercial aircraft.[1]

Aircraft Radio Altimeters

T-Mobile's reply comments quote a seven-year-old NTIA report to suggest that radio altimeters may not need the entire 4.2-4.4 GHz band to operate successfully.[2] The quoted NTIA report acknowledged that further study would be needed to determine the actual operational requirements of radio altimeters in cooperation with the International Telecommunication Union and the International Civil Aviation Organization.[3]

That further study was completed and is now incorporated in ITU-R Recommendation M.2059, "Operational and Technical Characteristics and Protection Criteria of Radio Altimeters

[1] *See* Reply Comments of T-Mobile USA, Inc., GN Docket No. 17-183, at 8-10 (Nov. 15, 2017) ("*T-Mobile Reply Comments*").

[2] *See* An Assessment of the Near-Term Viability of Accommodating Wireless Broadband Systems in the 1675-1710 MHz, 1755-1780 MHz, 3500- 3650 MHz, and 4200-4220 MHz, 4380-4400 MHz Bands, Department of Commerce at 2-6 (Oct. 2010) ("*2010 NTIA Report*"), *available at* https://www.ntia.doc.gov/files/ntia/publications/fasttrackevaluation_11152010.pdf.

[3] *See id.* at 1-7.

Utilizing the Band 4 200-4 400 MHz".[4] As explained in later sections of this letter, ITU-R Recommendation M.2059 concluded that radio altimeters require access to the entire 4.2-4.4 GHz band for their operations.[5] The Recommendation also observed that radio altimeters are highly susceptible to interference emanating from "both within its operational swept bandwidth as well as from outside this bandwidth."[6]

Based on Recommendation M.2059, the NTIA acknowledged in a subsequent 2014 report that ITU member states and international aviation organizations oppose further study of the 4.2-4.4 GHz band for mobile broadband services and NTIA recommended that the 4.2-4.4 GHz band be removed as a candidate for repurposing.[7] Consistent with this conclusion, the NTIA made no further mention of the 4.2-4.4 GHz band in its 2015 and 2016 reports on this same subject.[8]

Although T-Mobile was aware of NTIA's change of position, having cited to the 2014 NTIA report in its initial comments, including NTIA's decision to end further consideration of the 4.2-4.4 GHz band for mobile broadband,[9] T-Mobile nevertheless relied extensively on the NTIA's outdated 2010 report in its reply comments, failing to acknowledge that the 2010 report was superseded by ITU-R studies and by NTIA's 2014 report.

ITU-R Recommendation M.2059 clearly explains why radio altimeters require access to the entire 4.2-4.4 GHz band. Most radio altimeters installed today on large aircraft by Boeing and other manufacturers employ Frequency Modulated Carrier Wave ("FMCW") digital technology. These aircraft operate throughout the United States and worldwide. Digital FMCW altimeters transmit a very wide bandwidth signal toward the ground and determine the aircraft's altitude based on the time it takes the signal to reflect off the ground and back up to a separate receiver on

[4] Operational and Technical Characteristics and Protection Criteria of Radio Altimeters Utilizing the Band 4 200-4 400, ITU-R Recommendation M.2059 (Feb. 2014) ("*Recommendation M.2059*").

[5] *See, e.g., id.* at 11 (explaining the requirements of radio altimeters that use the full 200 MHz of bandwidth in the 4.2-4.4 GHz band).

[6] *Id.*, Annex 3, § 2.1.

[7] *See* Fourth Interim Progress Report on the Ten-Year Plan and Timetable and Plan for Quantitative Assessments of Spectrum Usage at 25, U.S. Department of Commerce at 25-26 (June 2014) ("*2014 NTIA Report*"), https://www.ntia.doc.gov/files/ntia/publications/fourth_interim_progress_report_final.pdf.

[8] *See* Sixth Interim Progress Report on the Ten-Year Plan and Timetable, U.S. Department of Commerce (June 2016); *available at https://www.ntia.doc.gov/report/2016/sixth-interim-progress-report-ten-year-plan-and-timetable;* Fifth Interim Progress Report on the Ten-Year Plan and Timetable, U.S. Department of Commerce (April 2015), *available at* https://www.ntia.doc.gov/files/ntia/publications/ntia_5th_interim_progress_report_on_ten-year_timetable_april_2015.pdf.

[9] *See* Comments of T-Mobile USA, Inc., GN Docket No. 17-183 at 20-21 (Oct. 2, 2017) (urging the Commission to "encourage NTIA to *resume* evaluation" of the 4.2-4.4 GHz band (*emphasis added*)).

the aircraft. The use of a larger bandwidth increases the accuracy of the altitude data. For this reason, representative digital FMCW altimeters used by Boeing and other manufacturers have bandwidths of 190, 195 and 196 MHz when measured at the -40 dB drop-off bandwidth,[10] as recommended by Recommendation M.2059.[11]

Boeing and other aircraft manufacturers install three radio altimeters on most large commercial aircraft, with the center frequencies spaced 5 MHz a part at 2.995, 2.300 and 2.305 GHz.[12] Thus, the bandwidth of the lowest signal extends to the lower edge of the band at 4.2 GHz.

Digital FMCW altimeters are highly susceptible to interference. An errant transmission in the 4.2-4.4 GHz band can mix with the FMCW waveform, causing the altimeter to mistake the mixed signal as terrain, potentially resulting in the altimeter reporting a false altitude.[13] Even an errant transmission in a small portion of the 4.2-4.4 GHz band can have harmful results because "the linearly varying frequency modulation of the altimeter causes a relatively narrow-band carrier that falls within or nearby to the edge of the altimeter modulation to be swept through some fraction of the altimeter's receiver passband."[14]

As noted above, digital FMCW altimeters are susceptible to interference transmitted both within the 4.2-4.4 GHz band and adjacent to the 4.2-4.4 GHz band. Recommendation M.2059 explains that although FMCW altimeter receivers employ bandpass filters, these filters have limited ability to reject transmissions close to the desired band.[15] As a result, altimeter performance can be affected by errant signals adjacent to the 4.2-4.4 GHz band.[16]

Harmful interference to radio altimeters can result from transmissions from within the aircraft or from anywhere on the ground. For example, a wireless consumer device inside an aircraft could inadvertently transmit near the upper edge of the 3.7-4.2 GHz band, potentially preventing the altimeter receivers on the aircraft from detecting the relatively weak telemetry signals reflected off the ground. Harmful interference could also result from transmissions originating from the ground at or near the 4.2-4.4 GHz band. As Recommendation M.2059 explains, altimeter receivers "do not have the benefit of being shielded or screened from many of

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[10] *See Recommendation M.2059* at 16, Table 2.

[11] *See id.* at 10-11.

[12] *See id.* at 10 (describing the use of three altimeters spaced 5 MHz a part).

[13] *See id.* at 9.

[14] *See id.*

[15] *See id.* at 11.

[16] *See id.*

the possible interference sources on the Earth's surface."[17] As a result, altimeter receivers "can virtually 'see' all possible radiation sources as they escape buildings and via direct transmission from devices operating outside of any structure."[18]

As Boeing detailed in its comments, radio altimeters are an essential component of the safe operation of aircraft during all phases of flight.[19] The data provided by radio altimeters is used as a height controlling sensor by the Automatic Flight Control System during automated approaches and landings.[20] In many aircraft, the radio altimeter is also directly connected to the Traffic Collision-Avoidance System and Automatic Dependent Surveillance-Broadcast System, which are used to monitor the airspace around an aircraft and to warn pilots of any threat of a mid-air collision.[21] Finally, radio altimeters are also used to support the Ground Proximity Warning System, which is designed to warn the pilot if the aircraft is flying too low or descending too quickly.[22] Given the critical importance of ensuring the reliable and highly accurate operation of radio altimeters, and their significant susceptibility to interference, the Commission should proceed very cautiously to ensure that any new use of the 3.7-4.2 GHz band does not cause potentially devastating interference to radio altimeters in the 4.2-4.4 GHz band.

Wireless Avionics Intra-Communications Systems

In urging the Commission to consider the potential for mobile broadband operations in or near the 4.2-4.4 GHz band, T-Mobile's reply comments completely disregard the recent introduction of WAIC systems operating throughout the 4.2-4.4 GHz band. WAIC involves the use of wireless communications systems within an aircraft to replace a potentially substantial portion of aircraft wiring.[23] Given the significant amount of communications that are necessary for the operation and monitoring of aircraft systems, WAIC systems require access to the entire 4.2-4.4 GHz band to function successfully.

NTIA explained in its 2014 report on spectrum repurposing (the report T-Mobile ignored in its reply comments) that international efforts to introduce WAIC systems in the 4.2-4.4 GHz

[17] *Id.* at 10.

[18] *Id.*

[19] *See* Comments of The Boeing Company, GN Docket No. 17-183 at 2-4 (Oct. 2, 2017).

[20] *See Recommendation M.2059* at 5.

[21] *See id.* at 6.

[22] *See id.* at 7.

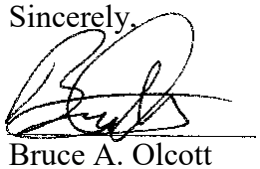
[23] *See, e.g.,* Presentation of the Aerospace Vehicle Systems Institute for Working Parties 5A, 5B, 5C, "Agenda Item 1.17 Wireless Avionics Intra-Communication" (May 23, 2012), *available at* https://www.itu.int/ITU-R/study-groups/docs/workshop-wp5abc-wrc15/WP5ABC-WRC15-P2-5.pdf.

band provided a second reason to remove this band from consideration for repurposing.[24] The 4.2-4.4 GHz band was specifically identified for WAIC systems because the spectrum was already allocated to safety-of-life aeronautical services and also because the spectrum was not proximate to other frequency bands used for mobile consumer devices such as smartphones, laptops, and tablets, all of which are routinely carried by passengers on commercial aircraft. If the upper portion of the 3.7-4.2 GHz band is made available for mobile wireless devices, however, the global aviation industry, including all U.S. airlines, would likely be forced to confront the substantial public safety problem of out-of-band emissions impacting the safe operation of aircraft.

Boeing recognizes the Commission's desire to facilitate the most efficient and flexible use of the 3.7-4.2 GHz band that can be safely accommodated while adequately protecting incumbent services in this and adjacent frequency bands. To this end, it is essential that any high density fixed or mobile services that are permitted by the Commission to operate in the 3.7-4.2 GHz band be restricted sufficiently to ensure that safety-of-life aviation services provided by radio altimeters and WAIC systems are protected adequately from harmful interference.

Thank you for your attention to this matter. Please contact the undersigned if you have any questions.

Sincerely,



Bruce A. Olcott
Counsel to The Boeing Company

[24] *2014 NTIA Report* at 25.